PART 1.00 - GENERAL

1.01 OWNER'S INTENT

A. To maintain complete compatibility with Owner's existing energy management system (EMS), use of a direct digital control system utilizing United Technologies unit control panels (UCP) is mandatory.

B. In order to obtain competitive bidding, and in an attempt to be impartial toward all contractors, Owner/Project Manager has detailed the EMS requirements and designated the acceptable EMS contractors in Section 15951.

C. Installing owner-furnished UCP enclosures and providing all other parts of the automatic temperature control / building automation system is part of Contractor's scope of work. Contractor shall test all EMS cabling according to Section 15952, and support the EMS commissioning effort according to Section 15953.

1.02 SECTION INCLUDES

A. Temperature controls including, but not necessarily limited to:

1. Installation of owner-furnished UCP enclosures.
2. Complete electronic sensing and actuation system, including:
    a. Conduit, trunking and cable.
    b. Temperature, humidity, and carbon dioxide sensors.
    c. Pressure, level, and flow measuring devices.
    e. Valves, dampers, and associated electronic actuators.
    f. Electronic thermostats and VAV box controllers.

B. All other building automation components as required by the AC-700 series drawings.

1.03 LABELS, CHARTS, AND IDENTIFICATION

A. All automatic control valves, dampers, and devices shall be labeled in an approved fashion.

B. Provide type-engraved phenolic nameplate with ¼ inch (6mm) high white lettering on black background, and clearly indicate the designation for all control items.

1. Use rivet-fastened nameplates for devices located indoors and glue-fastened nameplates for devices located outdoors.
2. For electronic actuators, drill a hole in the nameplate and attach with a wire-tie. For space sensors, attach inside sensor cover with double-face tape.
3. Designations shall consist of the UCP, System and Device names and Point Number from the UCP Panel Schedule.
4. Place a label on or near the duplex receptacle in the UCP indicating the electrical panel name and circuit designation.

C. Cable labeling:

1. Label both ends of control cables with the control point identification number as shown on the UCP panel schedule.
2. When multiple cables are associated with a single point (multistage heater control and status, or any device with multiple actuators, for example), label each cable with the common point number and different letters (typically will also be shown on the UCP panel schedule, but may not be.)
3. Label both ends of communications cables with the segment number indicated on the EMS block diagram. If four Belden 8772 or equivalent are used in lieu of Belden 1083A, further identify the individual cables with A, B, C, D.
4. Place a third label on each cable within 4 inches (100mm) of the point of entry to the UCP. If a wireway (trough, gutter, box) is used to connect multiple conduits to the UCP, then label the cables within the wireway also.
5. Minimum 1 inch (25mm) long cloth self-adhesive wraparound wire labels shall be used. The labels shall be by Thomas and Betts or Owner-approved equivalent.
6. Two single-digit labels shall not be used to create double-digit point or segment numbers.

1.04 COORDINATION

A. The final UCP location(s) shall be verified with Owner/Project Manager before mounting enclosures.

B. Verify Thread-O-Let or tee locations for pipe-mounted sensors with the proper installing contractor. Sensor locations may or may not be shown on plans and schematics.

C. Verify existence and final location of CUTB(s), CUTC(s), MCC(s), contactor cabinet(s), and stand-alone starter(s) with the appropriate installing contractor. Motor and lighting controls not detailed elsewhere on plans become part of this scope of work.

D. Coordinate control valve and damper locations with other trades to ensure actuator accessibility.

E. Coordinate proper porting of three-way control valves with the installing contractor. Valves shall be ported as described on plans and Specifications, but not necessarily as depicted on schematic diagrams.

F. Submit formal request for information to clarify location of devices required per AC-700 series drawings but not shown elsewhere on the plans.

1.05 SUBMITTALS

A. Submit equipment data sheets for all items furnished under this Section.

B. The submittals shall include the schedule of automatic control valves and the actuators to be used for each valve.

C. The submittals shall include the schedule of control dampers and the actuators to be used for each damper.

PART 2.00 - PRODUCTS

2.01 MATERIALS QUALITY

A. Refer to Section 15050.

2.02 OWNER-FURNISHED DEVICES

A. UCP: Enclosures and all internal control components.

2.03 AUTOMATIC CONTROL VALVES

A. Control valves shall be quarter-turn ball or butterfly valves by Belimo Aircontrols (USA), Inc., or Owner-approved equivalent. Valve bodies shall be nickel-plated forged brass with female pipe thread. Ball and stem shall be stainless steel.

B. Modulating control valves shall be sized for a minimum of 50% and not more than 120% of the scheduled coil pressure drop.

2.04 SENSORS FOR USE WITH UCP'S

A Temperature sensor:

1. General:
    a. Temperature sensors shall be either 10,000 ohm curve 3 thermistors or 1000 ohm nickel RTD's.
    b. Sensors shall be factory calibrated and shall not require compensation for cable length, etc.
    c. The sensing range shall be approx. -40°F to 240°F (-40°C to 115°C.) Above 240°F (115°C), an RTD with 4-20mA transmitter shall be required.
    d. Part numbers beginning with BA/ are from Building Automation Products, Inc. (BAPI), Gays Mills, WI USA (www.bapihvac.com).
    e. Paint all on-stage sensor housings to match adjacent surface.
2. Room air temperature:
    a. Sensors shall have a connection plate to permit easy removal of the sensor during decoration, etc.
    b. Subject to compliance with requirements, sensor shall be thermistor type equivalent to BA/10K-3-R-N (Carrier T55) for back-of-house areas, and BA/10K-3-R for on-stage guest areas or approved equivalent.
3. Duct Air Temperature:
    a. Ducts less than 18 inches (450mm): Thermistor type equivalent to BA/10K-3-D-4 (Carrier T42S).

b. Ducts 18 to 48 inches (450mm to 1200mm): Thermistor type equivalent to BA/10K-3-D-18 (Carrier T42L).

c. Ducts over 48 inches (1200mm): Averaging RTD type equivalent to BA/1K[Ni2]-A-24' (Carrier T49) or as necessary to traverse the duct four times.

4. Water temperature:

a. For immersion temperature sensors, provide with machined stainless steel thermowells.

b. Subject to compliance with requirements, sensor shall be thermistor type equivalent to BA/10K-3-I-4 (Carrier T44L.)

B. Water flow:

1. Analog output water flow sensor shall be equivalent to the following by Data Industrial:

a. Model 250B with Model 310 transmitter for pipe sizes less than 1.5" (40mm.)

b. Model SDI-2-H1-N-1-0-0200 for pipe sizes 1.5" to 10" (40 to 250mm.)

c. Model SDI-2-H2-N-1-0-0200 for pipe sizes 12" to 36" (300 to 900mm.)

d. Model SDI-2-H3-N-1-0-0200 for pipe sizes over 36" (900mm.)

2. Pulse output water flow meter shall be, subject to Project Manager approval, any suitable utility-grade water meter with low-frequency pulse output equivalent to the following:

a. Badger Meter RCDL positive displacement meter with "RTR" pulse output transmitter/register for flows up to 170 gpm and pipe sizes ½" through 2".

b. Siemens Model 1020N-NS ultrasonic flow meter for flows greater than 170 gpm and pipe sizes above 2".

C. Cold deck, hot deck, OSA precooling coil, mixed air temperature sensors shall be RTD averaging type equivalent to BA/1K[Ni2]-A-24' or as necessary to traverse the coil 4 times.

D. Filter differential pressure switch:

1. Filter differential pressure switch shall be single-pole, double-throw differential pressure switch

2. Subject to compliance with requirements, filter differential pressure sensor shall be equivalent to BA/ZPS-SW3, with range adjusted as appropriate for required service. Turn over spare range springs to owner.

E. Humidity sensor, 2 wire, 4 – 20mA type shall be equivalent to:

1. BA/H200-D-WP, or Vaisala HMD 60U for duct mounting.

2. For wall mounting:

a. If onstage in guest view, use BA/10K-3-H200-R combination temperature and humidity sensor.

b. If backstage or in dark ride, separate BA/H200-R or Vaisala HMW 60U may be used.

F. Supply duct and building static pressure transmitter shall be two-wire, 4-20mA, 0-5”WC (0-1250Pa) BA/ZPS-20-SR05-BB-AT or approved equivalent.

G. Water and air pressure sensor:

1. Sensors shall be loop powered and shall vary a 4-20mA signal with a change in pressure. Outdoor sensors shall have weatherproof housing.

2. Subject to compliance with requirements, the pressure sensor shall be Setra Model 256, with range appropriate for required service or owner-approved equivalent.

H. Water level sensor (analog)

1. Water level sensors shall be ultrasonic level transmitter type with linear 4-20mA output. Install stilling well (pipe) if water surface will be turbulent.

2. Subject to compliance with requirements, water level sensors shall be Kobold EchoKing NEO-5000 series or approved equivalent.

I. Water differential pressure switch:

1. Differential pressure switches for water services shall be single-pole, single-throw type and operated by stainless steel bourdon tubes.

2. Contacts shall be hermetically-sealed and mercury wetted.

3. Subject to compliance with requirements, differential pressure switches shall be Dwyer-Mercoid or approved equivalent with range appropriate for required services.

J. Water differential pressure sensor:

1. Differential pressure sensors shall be loop powered (2-wire) and shall vary a 4-20mA signal with a change in differential pressure.

2. Subject to compliance with requirements, the differential pressure sensor shall be Setra Model 230 with option “3V” 3-valve manifold assembly, with range appropriate for required service or owner-approved equivalent.

K. Water level switch:

1. Pit water level switches shall be dual probe type, conductance actuated.

2. Subject to compliance with requirements, boiler water level switches shall be McDonnell and Miller Model PCH or approved equivalent.

3. Break tank water level switches shall be float type with 1FormC contacts.

L. Airflow switch:

1. Air flow switches shall be operated by a stainless steel vane actuating a single-pole, double-throw switch.

2. Vane motion shall be restrained by a calibrated spring adjustable to the exact actuation point required.

3. Subject to compliance with requirements, air flow switches shall be Dwyer No. 530 or Owner-approved equivalent.

M. Condensate float switch shall be adjustable high-level condensate switch equivalent to Becket No. 1502 or Owner-approved equivalent as required to meet local codes.

N. Carbon Dioxide (CO_2) sensor:

1. Duct Mount:

a. The CO_2 sensor shall comprise a diffusion gas chamber that should incorporate a gas permeable filter that prevents particulate and water contamination of the sensor.

b. For long-term stability, the sensor shall utilize a dual channel infrared detector, open channel for CO_2 absorption, the other for reference to correct for long-term sensor drift.

c. The sensor shall incorporate elevation correction adjustment and have an accuracy of ±50ppm or 7% at temperatures of 59-90°F (15-32°C.)

d. The sensor shall be installed in a duct-mounted aspiration box with air sampling probe protruding into the air stream. The same manufacturer shall supply both CO_2 sensor and aspiration box.

e. Subject to compliance with requirements, the CO_2 sensor shall be Carrier No. 33ZCSENCO2 with No. 33ZCASPCO2 aspirator box, or by Telaire or approved equivalent.

2. Wall mount:

a. Applications requiring temperature, humidity and CO_2 shall be BA/BS3X-IEQ10-H212-102-N-OFW or Owner-approved equivalent. Add -90L6 to part number if setpoint adjustment is required.

b. Applications requiring temperature and CO_2 sensor shall be BA/BS3X-IEQ10-102-N-OFW, Carrier No. 33ZCT55CO2 or Owner-approved equivalent.

O. Air flow sensor:

1. Duct air flow sensor shall be, subject to owner approval by Dwyer or Kurz, with pressure and flow range suitable for the application.

2. Compressed air flow sensor shall be by CDI Meters, Inc., model CDI 5200 for steel and copper pipe sizes ¾" to 2", and model CDI 5400 for steel and copper pipe sizes 2.5" to 6".

2.05 ELECTRICAL

A. All enclosures containing control devices or terminal blocks used for EMS purposes shall have latching hinged covers. Outdoor enclosures shall be NEMA 4X (IP66.)

B. Relays shall be low-power, 24 VDC, two-pole, double-throw type, equivalent to IDEC RH2BU with SH2B-05 socket.

C. Current sensing relays (current switches) shall be equivalent to Veris Industries Model 800.

D. All control wiring connected to the UCP shall be 20-gauge twisted-shielded stranded pair cable (equivalent to Belden No. 8762) or 18-gauge four-conductor cable (equivalent to Belden No. 8489) according to the UCP panel schedules.

E. UCP communications cable shall be 4 nos. 20 gauge, twisted, shielded stranded triads, equivalent to 4 nos. Belden No. 8772 or a single Belden No. 1083A.

F. Thermostat and VAV box controller communications cables shall be Belden No. 8770 or Owner-approved equivalent.

G. Four-wire sensors (where used) shall be connected using the four conductor cable regardless what is shown on the UCP panel schedule.

H. Required motor controls not detailed elsewhere on the plans or specifications shall adhere to applicable electrical codes and regulations.

I. EMS underground communications cable shall be by Superior Essex, P/N: 04-057-21 (Anixter P/N: E000622AFC), 6P#22 solid, gel-filled, 8-mil aluminum shield.

2.06 AUTOMATIC DAMPERS (WITH DAMPER ACTUATORS)

A. Provide, as part of work of this Section, all automatic dampers for installation under Section 15400.

B. Dampers shall be low leakage (less than 2% of full flow at 4” WC (1000Pa) differential pressure across the damper) with opposed extruded aluminum airfoil blades.

C. Separate actuators shall be provided for each damper section.

2.07 THERMOSTATS, VAV BOX AND FAN COIL CONTROLLERS

A. Line voltage: Equivalent to Honeywell model T651A.

B. VAV box and Fan Coil controllers:

1. Non-powered VAV boxes shall utilize Carrier No. 33ZCVAVTRM controller.

2. Fan-powered VAV boxes shall utilize Carrier No. 33ZCFANTRM controller.

3. Fan coil units, where specified, shall utilize Carrier No. 33ZCFANCOL controller.

4. Room sensors:

a. Applications requiring temperature only shall be thermistor-type equivalent to BA/10K-2-R-90L6-N-DF (Carrier T56).

b. Applications requiring temperature and humidity shall be equivalent to BA/10K-2-H212-B4X-90L6-N-DF-WMW.

c. Applications requiring temperature and CO_2 sensor shall be equivalent to BA/BS3X-IEQ10-102-N-OFW (Carrier No. 33ZCT56CO2).

d. Applications requiring temperature, humidity and CO_2 shall be BA/BS3X-IEQ10-H212-90L6-102-N-OFW.

e. All room sensors shall have a setpoint adjustment slider and override pushbutton which shorts the temperature sensor circuit.

5. Hot (and/or chilled) water control valve actuators shall use floating-point (tri-state) control compatible with the controller, by Belimo Aircontrols (USA), Inc.

6. Supply air temperature shall be 10K ohm curve 2 thermistor type equivalent to BA/10K-2-D-4.

7. Provide 24VAC transformer with primary rated for the box/fan coil supply voltage, or for the dedicated power circuit provided by division 16.

8. Mount controllers and control transformers within the box/fan coil control enclosure. If no control enclosure available on unit, then provide enclosure with hinged latching cover.

9. Electric heaters shall be controlled in two steps, so if more than 2 stages are provided, stages must be grouped. Electric heaters over 10kW should be ordered with SCR control.

2.08 ELECTRONIC ACTUATORS FOR TEMPERATURE CONTROLS

A. Valves and dampers requiring modulation shall utilize Belimo quarter-turn actuators with spring return, 24 VDC power, 2-10 VDC control signal, 2-10 VDC feedback signal, and shall have sufficient power to actuate the device under full pressure. Acceptable models are Belimo No. AFB24-SR US, NFB24-SR US, and LF24-SR US. Provide multiple actuators if required for proper torque.

B. Valves and dampers requiring two-position actuation shall utilize Belimo quarter-turn actuators with spring return, 24 VDC power with end of run limit switch, and shall have sufficient power to actuate the device under full pressure. Acceptable models are Belimo No. AF24-S US, NF24-S US, and LF24-S US. Provide multiple actuators if required for proper torque.

C. Each electronic actuator shall be connected directly to the UCP using a separate four-conductor, 18-gauge cable, Belden No. 8489 or Owner-approved equivalent. Isolated power supply for each actuator shall be provided at the UCP, and branching of common signals shall be done only in the UCP.

D. Field termination of electronic actuators shall be accomplished with mating quick-connect plugs having screw terminal connections, BA/BELCON, or Owner-approved equivalent.

E. Actuators to be installed outdoors shall be furnished with hinged, latching weather-shield enclosures, with conduit entering from the bottom only.

F. For valves on insulated pipes, provide valve neck extension kit (Belimo No. CCV-EXT-KIT) to allow actuator to be installed above the insulation.

G. For Belimo Pressure Independent Characterized Control Valves (PICCV), provide LF24-MFT or AF24-MFT actuators programmed for 2-10VDC input with 2V corresponding to the normal (spring-returned) position, and 10V corresponding to the full-stroked position.

H. For large isolation valves requiring more torque than two AF actuators, use Belimo SY style with line voltage motors. Run minimum 14 gauge power cable separate from signal and feedback. Coordinate power circuit assignment with Division 16.

2.09 BOILER CONTROLS

A. Provide relay for boiler start/stop which shall be installed in boiler control panel if possible. Do not switch power to control panel. Wire normally open relay contacts to the boiler "remote start" terminals, or in series with the "on/off" switch as necessary.

B. Provide additional relays if necessary to obtain contact closures when boiler is running (gas valve is open), and when it is in alarm (any shutdown which requires a manual reset).

C. Provided a relay box adjacent to boiler if staging relays do not fit in control panel or if boiler isolation valves require control relays.

D. Provided sufficient relays and cables to control and monitor each stage of the boiler separately, as well as each isolation valve (regardless what is shown on panel schedule.)

2.10 DX EQUIPMENT

A. Controlled by UCP's.

1. Use BA/UCRB interface board. Terminate controller outputs on left, thermostat cable on right, from top to bottom, R, G, Y1, Y2, W1, W2, and O. BA/UCRB will normally be installed in UCP.

2. Provide sufficient conductors from the equipment to the UCP in order to control each stage of cooling, heating, reversing valve, etc. separately.

3. Terminate fire alarm relays, hood control relays, or duct smoke detectors in series with the 24VAC supply wire "R".

B. Controlled by PremierLINK.

1. Unless otherwise specified, DX equipment (especially heat pumps) shall be controlled using Carrier "PremierLINK" controllers with space temperature, setpoint adjust, supply air temperature, and fan status inputs. Standard DX control points shall be used. Provide BA/PLCON1 and BA/PLCON2 interface connectors for cable terminations.

2. Space temperature/setpoint adjust shall be equivalent to BA/10K-2-RSO.

3. Supply air temperature shall be equivalent to BA/10K-2-D-18.

4. Where specified, analog economizer damper control and CO2 sensor may be required.

5. Wall mount CO2 sensor, current relay for fan status, and damper actuator shall be the same as described for UCP's.

C. Controlled by Fan Coil Controller.

1. If humidity control is specified, DX equipment shall be controlled using Carrier No. 33ZCFANCOL controllers with space temperature, space humidity, setpoint adjust, supply air temperature, and fan status inputs. Standard DX control points shall be used.

2. Provide Terminal Unit Relay Board (BA/TURB) to interface between controller and the DX unit's thermostat terminal block.

3. Sensors shall be as described above for PremierLINK.

2.11 ELECTRIC HEATER CONTROLS

A. Provide relay for heater start/stop which shall be installed in heater control panel if possible. Connect normally open relay contacts into the control circuit.

B. Provided sufficient relays and cables to the UCP to control each stage of the heater separately, up to four stages (regardless what is shown on panel schedule.)

C. A relay box shall be provided adjacent to heater if relays do not fit in control panel.

D. For heaters with more than four stages, group the stages and control in 4 steps. Electric heaters over 10kW should be ordered with analog SCR control.

E. If electric heater is controlled remotely from an MCC, provide also status cables from the auxiliary contacts on each stage's contactor (regardless what is shown on panel schedule—label with the control point number and additional letters.)

F. Electric heaters shall be provided with air-flow switch and high-temperature cut-out safeties as required by local codes.

PART 3.00 - EXECUTION

3.01 INSTALLATION

A. Refer to Section 15050.

B. Unit controllers: Install UCP enclosures supplied by Project Manager and pull all wiring into the enclosures. UCP enclosures shall be wall mounted at a maximum of 72 inches (1800mm) to top of enclosure from finished floor and with a minimum of 36 inches (600mm in HK) clearance in front of enclosure.

C. All cables entering UCP shall have minimum 10 feet (3m) of slack to allow for EMS Contractor termination. A minimum of 10 feet (3m) slack shall be left on all EMS cables at CUTBs and PIC racks and 3 feet (1m) of slack shall be left at all EMS remote communications boxes.

D. Terminate control cables at sensors and actuators in accord with manufacturer's instructions provided with the device. Do not terminate shield drain wires. Provide all instruction sheets to Owner/Project Manager as part of the O&M Manual.

E. Unless unavoidable, all damper actuators shall be installed outside of airstream.

F. Install actuators in such a way that they are accessible, and may be removed without removing the controlled device, and without removing other piping, conduit, equipment, or components.

G. Motor, Lighting, and Miscellaneous Electrical Controls

1. Control and status cables shall be terminated on terminal blocks provided in MCCs, stand-alone starters, contactor cabinets, and/or other enclosures when control diagram is shown on drawings.

2. Provide control transformer, control relay, current-sensing status relay, alarm relay(s) and terminate as necessary when control diagram is not specifically shown on drawings.

3. Where multiple control or status devices are provided for a single EMS point, install multiple cables to the UCP and terminate each device.

4. Provide a terminal box adjacent to each MCC for transition from 300V control cable to 600V wire. Enter MCC with 600V wire only.

H. Sensors:

1. Mount room sensors at 54 inches (1350mm) above finished floor unless directed otherwise, verify with Owner/Project Manager for location prior to installation.

2. Mount duct sensors at not less than 6 feet (1.8m) downstream from coils or dampers, but before the first supply air drop. Sensor locations will not be shown on drawings.

3. For outdoor equipment:

a. Install duct sensors below roof if accessible for roof-mounted equipment; otherwise, sensors shall be installed in NEMA 4X (IP66) enclosures on the bottom or north side of the duct.

b. Install all other outdoor sensors in NEMA 4X (IP66) enclosures.

4. Averaging sensors:

a. Install averaging sensors in the shape of a “W”. Cold deck sensors shall be supported from the duct or frame of the coil at the points and ends of the “W” only. Avoid touching the element directly to the coil, fins, or frame.

b. Averaging mixed air sensor may be installed on the air diffuser baffle (if provided) after the supply fan on blow-through units.

c. Averaging mixed air sensor may be replaced with a BA/10K-3-D-18, bracket-mounted in the supply fan discharge on blow-through units if the opening is less than 38 inches (960mm) square (not applicable for plenum fans).

d. Averaging cold deck sensor may be replaced with BA/10K-3-D-18 duct mounted after the fan and before a duct-mounted heater/heating coil on draw-through units.

e. If a required cold deck sensor cannot be installed between the cooling coil and heating coil, install a water temperature sensor in the cooling coil chilled water return pipe.

5. Install water temperature sensors in thermowells fully inserted into the flow. For pipes under 2 inch (DN50), install the well axially into the pipe using a tee in place of an elbow. Fill the air gap between the well and the sensor with heat-conducting medium.

6. Install a condensate float switch on primary drain pan of each fan coil unit installed above a ceiling or exposed over electrical/electronic equipment or as indicated on Drawings. Cable shall be connected to normally open contacts and the float switch shall be adjusted to close with no more than half an inch (12mm) of standing water above the drain opening.

7. Install water flow meters in straight pipe with minimum 10 pipe diameters upstream and 5 pipe diameters downstream free of any other fittings. Compressed air flow meters require 30 pipe diameters upstream and 5 pipe diameters downstream free of fittings and other obstructions.

8. Pipe mounted sensor locations may or may not be shown on any drawings; coordinate locations early to avoid abortive works.

9. Install all sensors in accord with manufacturer's recommendations.

I. Valves:

1. Install three-way hot water valves with the normally closed port to the coil outlet, normally open port to the supply bypass, and the common port to the return line.

2. Kitchen condenser, HPU cooler, and other backup cooling systems require four two-way valves. Use a normally closed two-positon valve on the chilled water supply, normally open two-positon valves on the industrial cold water, and the drain, and a normally closed modulating valve on the chilled water return.

3. Install three-way chilled water valves with the normally closed port to the supply bypass, normally open port to the coil outlet, and the common port to the return line. Used exclusively on small CHW systems with a dedicated chiller.

3.02 WIRING

A. Install, connect, and wire the items included under this Section. This work includes the provision of the required conduit, wiring, fittings, and related wiring accessories. Install all wiring in conduit. All outdoor conduits and junction boxes shall be watertight.

B. Size, route, and install all conduits and trunking required for items included in this Section. Do not exceed the following EMS cable quantities for each conduit or trunking (wire trough, gutter, any rectangular raceway) size noted:

Conduit Size	No. of Sensor Cables (Belden 8762)	No. of Actuator Cables (Belden 8489)
½ in.	3	2
¾ in.	6	3

1 in.	10	6
1-1/4 in.	18	11
1-1/2 in.	24	15
2 in.	40	25

Trunking Size	No. of Sensor Cables (Belden 8762)	No. of Actuator Cables (Belden 8489)
2” x 2”	50	30
4” x 2”	110	70
4” x 4”	200	125
6” x 6”	460	280

C. Provide a junction box with duplex receptacle (dual socket outlet) and cover inside UCP enclosure. Install socket outlet horizontally in the lower left corner near the front of the UCP enclosure facing up. The power circuit to the socket shall be provided by Division 16. Connect conduit and power circuit directly to socket outlet through the bottom of the enclosure. Provide a ground terminal inside the panel for the connection of ground (earthing) conductor by Division 16.

D. Provide a junction box with a minimum of 12 inch (300mm) long flexible conduit for the connection of each electronic actuator. Do not shorten the coiled cable provided with actuator. Connect the coiled cable to UCP cable in the junction box in accord with Paragraph 2.08.D above.

E. Cable conductor color codes:

1. Sensor cables: Black is always negative (-). Clear, white, or red is positive (+), depending on cable type used.

2. Modulating electronic actuators: Black is 0 VDC power common, red is 24 VDC power (+), white is 2-10 VDC signal, and green is 2-10 VDC feedback. Cables must follow this color code.

3. Electronic thermostat communications cable: Red is signal positive (+), black is signal negative (-), and clear/white is signal ground.

4. Two-position actuators: Black is 0 VDC power common, red is 24 VDC power (+), white is the common (S1 on LF and NF, S4 on AF) contact on the end switch, and green is the normally open (S3 on LF and NF, S6 on AF) contact on the end switch. Cable must follow this color code.

F. EMS cables shall not be run within the same conduit with power circuits (120 VAC and above). Each EMS cable shall be a continuous run; make no splices.

3.03 START-UP AND SUPPORT

A. EMS Contractor shall install UCP components within the enclosure, terminate cables within the enclosure, and provide required start-up of these components.

B. Temperature Control Contractor shall support this start-up and commissioning effort with a sufficient number of control technicians to quickly troubleshoot and correct malfunctions in all portions of the system (except the controllers) in accordance with section 15953.

C. EMS Contractor shall not assist mechanical contractor's air and water test and balance efforts as part of the EMS scope of work. If EMS support is required during test and balance, mechanical contractor shall make separate arrangements.

3.04 TEMPERATURE CONTROL SYSTEM TEST PROCEDURE

A. Temperature Control Contractor shall test and verify all EMS cables, sensors, and connections to the satisfaction of Owner/Project Manager Contractor according to section 15952 of this section before UCP components are installed.

B. Adjust all dampers and valves for smooth operation. Adjust actuators to provide proper system sequencing before UCP components are installed. With no power to actuators (in the spring-return position), the following shall be true:

1. Chilled water valves are open, or ported to the coil with no bypass.
2. Hot water valves are closed, or ported to the bypass with no flow in the coil.
3. Multizone dampers are open to the cooling coil and closed to the bypass.
4. Outdoor air dampers
    a. On units with less than 50% outside air are closed.
    b. On units with more than 50% outside air are open.
5. Exhaust air dampers
    a. If dedicated to an exhaust fan are open.
    b. If part of an economizer mixing box are closed.
6. Return and transfer air dampers are open.
7. UCP-controlled volume (VAV) dampers are open.
8. Chilled water backup valves are ported for industrial cold water to flow through the cooled equipment to drain (closed to chilled water supply and return).

C. Notify Owner/Project Manager in writing when cabling to each UCP is completed and tested. Written notification shall consist of completed cable test check lists (available upon request from Owner/Project Manager) for each UCP and shall constitute Contractor's guarantee that all cables have been properly labeled, terminated, and tested, and that all control devices function properly.

END OF SECTION